NASA ASTROBIOLOGY EARLY CAREER AWARD

Activities Report

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Project: Detection of extraterrestrial biosignatures using a pattern recognition model (PRIMO)

Collaboration team: Dr. Lynn J. Rothschild; Dr. Ivan Paulino-Lima.

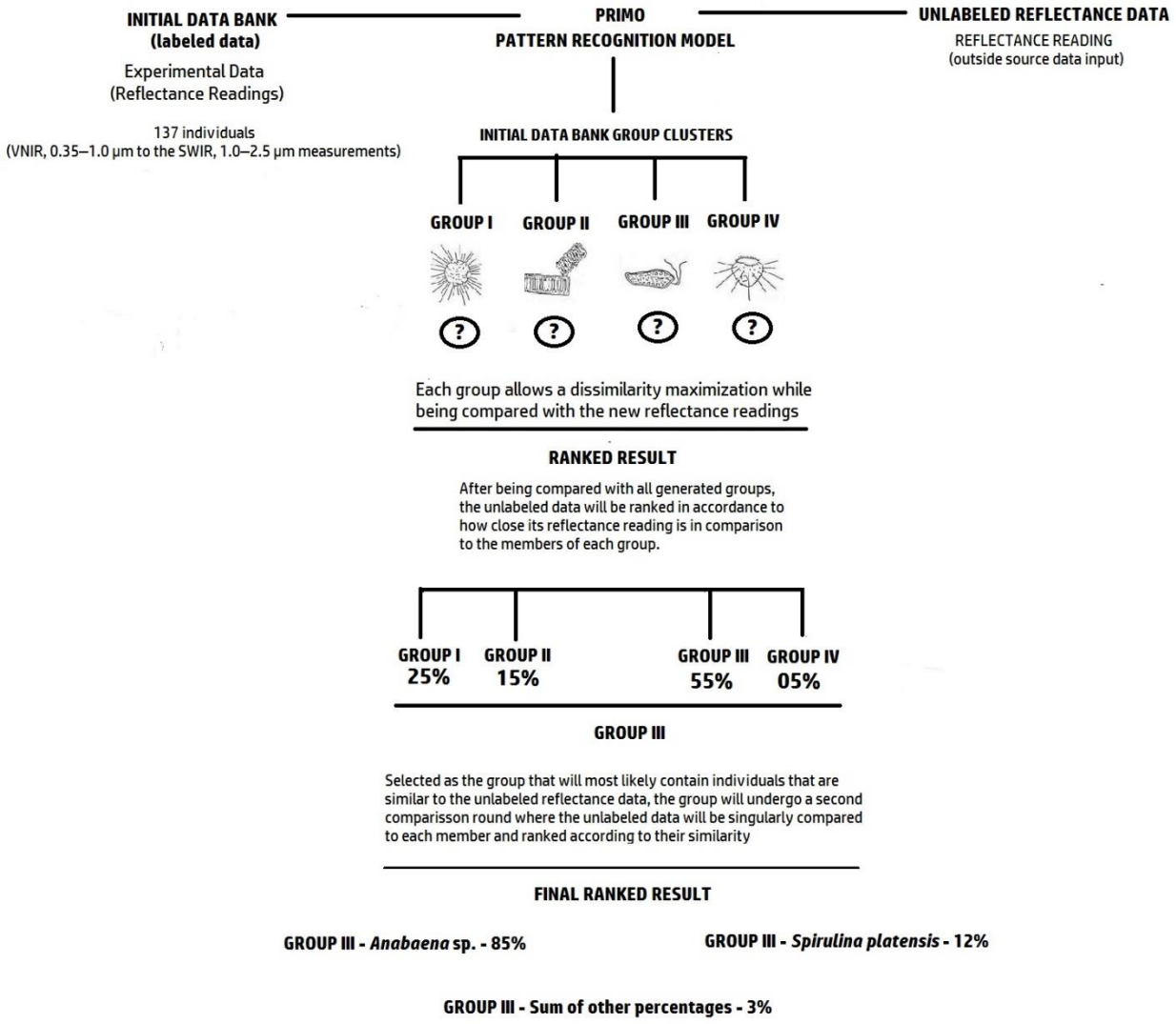
This collaboration contributed to the proper design and future usage of the resulting model in Astrobiology and early Earth projects. It was consisted of two phases: a project discussion phase and an experimental phase. The first phase was composed of a critical discussion between the involved parties of the experimental data that will need to be acquired (i.e., experimental design or access to already established hemispherical reflectance databases) to generate a pattern recognition model capable of identifying potentially habitable zones in exoplanets. Once the planned protocol was established, the group began to collect hemispherical reflectance data from non-catalogued organisms, complementing already established databases to be fed into the model. Most of the experimental phase data was acquired during the visit (hemispherical reflectance databases organization) and complementary test runs will be done remotely. The development and calibration of the model is underway and should be ready for publication by early April 2016.

Paper Abstract:

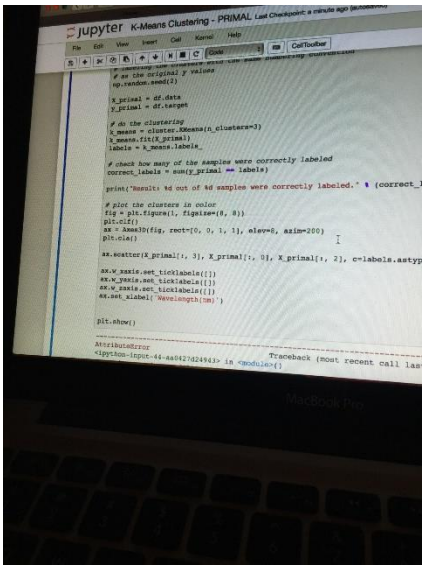
Many articles have discussed possibilities concerning the evolution of photosynthetic life on other planets and how it may differ from the development of similar life on Earth. However, although interesting and very relevant, these results have never been fully tested nor has a structural construct been developed to fully explain those results or allow testing of alternatives. The objective of this study is to use the spectral characteristics of 137 phylogenetically diverse microorganisms, containing a range of pigments, in the form of reflectance readings in order to gather sufficient knowledge to develop, populate and validate a reliable pattern recognition model of likeness of individuals. Reflectance results gathered from a digital spectral library will provide high-resolution chemispherical reflectance measurements for the model from the visible and near-infrared (VNIR, 0.35–1.0 μm) to the short-wavelength infrared (SWIR, 1.0–2.5 μm) as the initial data input. The purpose of the model will be to, as it receives unlabeled reflectance datasets (from an exoplanetary source), it will rank the initial database (collected from earth individuals) searching for a pattern on how similar the unlabeled exoplanetary data to the individuals that compose the model's original data bank. The structure of the model will be designed to have broad application to astrobiology and our

understanding of life on Earth. The model, in its first version, will cover most aspects of unicellular organisms regarding pigment composition. However, it also has the potential to be enriched with more variables in the future (i.e. temperature or pH) allowing it to be used as the base for other models capable to create an exoplanetary individual construct based on earth organisms experimental data banks.

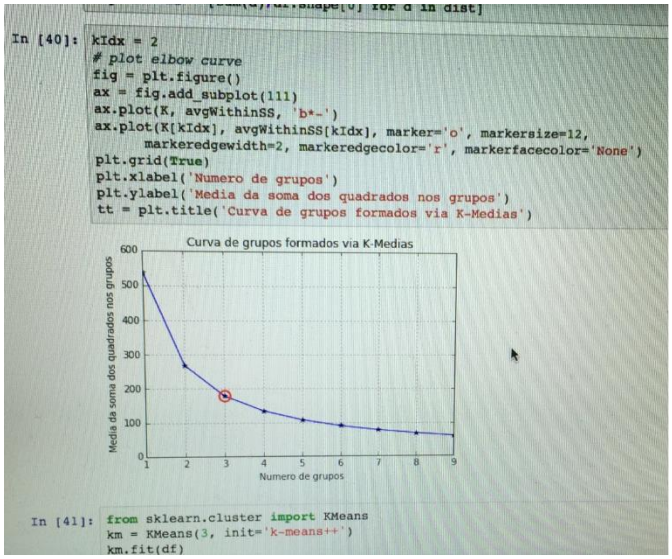
Model layout:



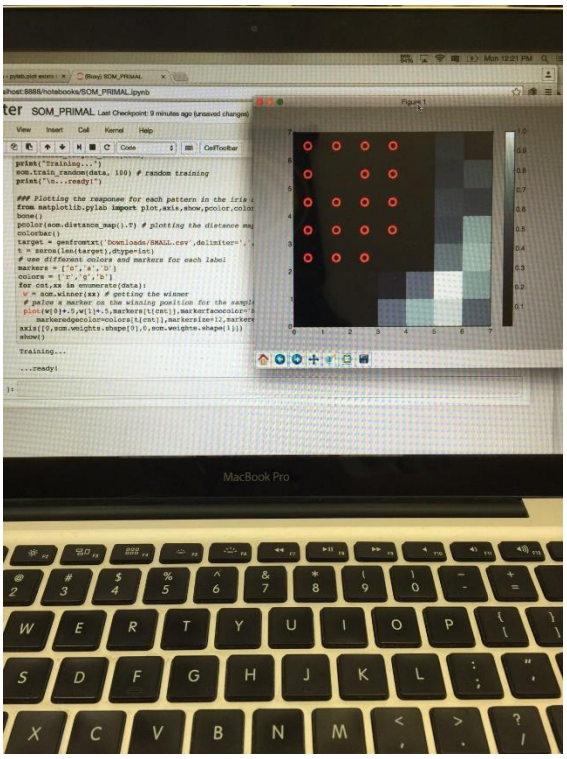
Model development pictures:



Picture.1. Labeling data for cluster formation



Picture.2. Perfect clusterization after K-means test showing 3 distinct groups



Picture.3. Self-Organizing Map (SOM) learning the patterns of the distinct hemispherical reflectance readings.

Picture.4. While not at meetings with the group I was mostly In front of the computer working on the model's math.